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SPECIFIC GRAVITY — DRY MATTER RELATIONSHIP IN POTATOES[1]

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INTRODUCTION

Factors affecting potato quality have been investigated for many years. A comprehensive review of the literature on this subject has been published by Sweetman (5), covering the period from 1895 to 1936. A similar review by Rose and Cook (3) covers the period from 1938 to 1948. In general, there is good agreement among researchers that potato quality is directly associated with variation in dry matter content. Because of its relationship to dry matter content and the rapidity and relative ease with which it may be determined, specific gravity has been proposed as a criterion or index of potato quality.

In connection with studies at North Carolina on the canning of small whole potatoes, the use of specific gravity as an index of dry matter content and cooking quality was contemplated. A review of literature revealed equations for predicting dry matter content from specific gravity.

[1] Approved for publication as paper No. 393 of the Journal Series of the North Carolina Agricultural Experiment Station.

Dunn and Nylund (2) report such an equation for potatoes from Minnesota and Scheele, Svennson and Rasmusson (4) for potatoes from Germany. Both groups of workers present the relationship between the two variates as a linear one.

There was considerable question as to the adaptability of these equations to the potatoes of North Carolina due to differences in cultural, environmental, varietal and other factors associated with the production of potatoes. An investigation was made, therefore, to determine the relationship between the specific gravity and dry matter content of recently harvested potatoes produced in North Carolina. The study had several novel features. Field samples of commercial potatoes were taken on a State-wide basis. The sampling plan was such that there was obtained a single equation which was truly representative of the State as a whole. Estimates were made of the effects of location of production, variety and size of tuber on the relationship involved. There was obtained an estimate of the error to be expected if the single equation is used to predict the dry matter content of a sample chosen at random without regard to variety, tuber size and location of production in the state.

Materials and Methods

Studies were conducted during two seasons, 1948 and 1949. The 1948 study was somewhat limited in scope and of preliminary nature. It provided experience in technique and furnished evidence that a more comprehensive study was needed.

The material for study in the 1948 season involved potatoes from plantings in one location in the eastern and one in the western potato-producing areas of North Carolina. Six varieties of potatoes were represented, and four of the six varieties were common to both locations. Each field sample consisted of approximately 100 pounds of potatoes of the canning type, *i. e.* small whole potatoes one to one and one-half inches in diameter.

The study in 1949 consisted of three parts: (1) a state-wide sampling of commercially grown potatoes, (2) a study of varietal effects based on samples from experimental plots, and (3) a study of the effects of size of tuber, also based on samples from experimental plots. Part 3 was included because parts 1 and 2, as well as the 1948 study, were conducted only with potatoes of canning size.

In order that the state-wide sample would provide an unbiased estimate of the specific gravity-dry matter relationship for the state as a whole, and also would provide a good estimate of the variance of the relationship over the state, the following sampling plan was adopted:

Counties harvesting in excess of 1,000 acres in eastern and 700 acres in western North Carolina, were selected from the counties located in

the important potato-producing areas of the state. These selected counties were subdivided into their respective townships and the ratio of total potato acreage to number of potato farms was calculated for each township. Townships, where this ratio exceeded four acres and one acre per farm in eastern and western North Carolina respectively, were included in the sampling. Certain of the selected counties, when examined by township, failed to meet these requirements. The selected counties with one or more townships satisfying the restrictions were sampled in proportion to the percentage of the total crop represented by that county. Within each county sampled, the township and grower providing the sample was selected at random. Growers were chosen from quota lists maintained by Production and Marketing Administration offices at the county seats. The originally selected counties together with the counties sampled are shown in figure 1. The dots represent the approximate location of each sample taken and give indication of the areas of intensive production. Note that the production of commercial potatoes is confined to two fairly distinct areas in the state, one in the east and one in the west. Twenty farms representing ten counties were sampled in the eastern area, and ten farms representing seven counties in the western area. Each sample consisted of 200 pounds of canning type potatoes. Cobbler is the most extensively grown variety in the east as is the Sequoia variety in the west. Hence, all eastern samples were Cobblers and all western samples Sequoias.

Varietal data were obtained from canning type potatoes of fourteen varieties grown at four locations. These locations were vegetable crop field stations located in the strategic producing areas of the state. Three of the varieties were common to all locations, three others to three locations, three additional to two locations, and five varieties were available at a single location.

For data on size of tuber, field-run potatoes of five varieties from a single location were graded into five size classes (1-1½, 1½-2, 2-2½, 2½-3, 3-3½ inches). Data were obtained on the specific gravity-dry matter relationship for each size class of each variety. On certain varieties some size classes were not available.

Upon delivery to the laboratory the field samples were washed and broken down into specific gravity* classes by the method of Clark *et al* (1). Because the lots were large, a wide range of specific gravity was observed in nearly all samples in the state-wide study. Some field samples available in the varietal and size studies were rather small, and in these cases more narrow ranges of specific gravity were observed.

From each specific gravity class a random sample of potatoes was selected. These were thoroughly washed to remove salt and were dried

*Specific gravity referred to water at 60° F.

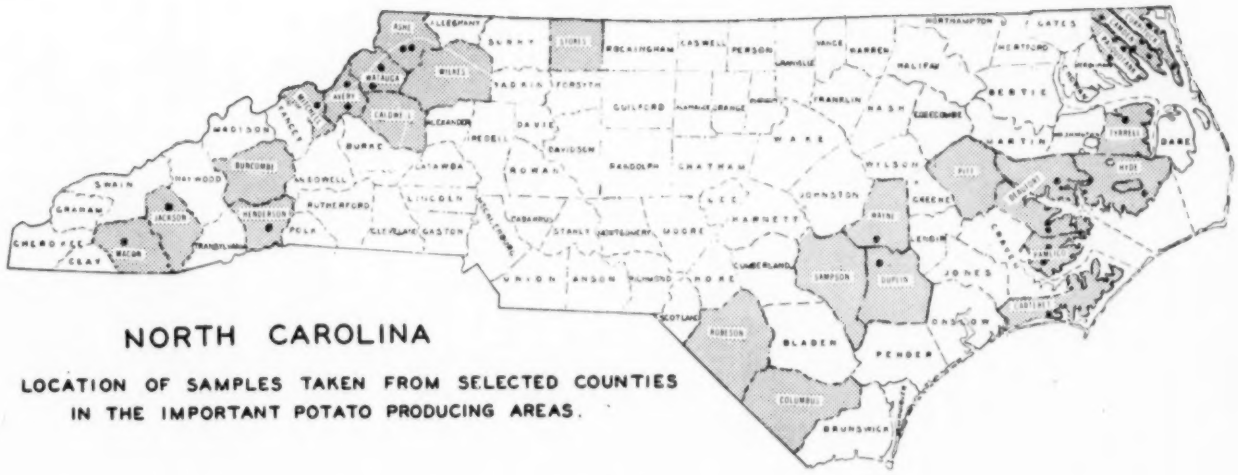

NORTH CAROLINA
LOCATION OF SAMPLES TAKEN FROM SELECTED COUNTIES
IN THE IMPORTANT POTATO PRODUCING AREAS.

Fig. 1

in an air blast at room temperature to remove external water. The sample from each specific gravity class was shredded. The resultant mass of shreds was thoroughly mixed and a 50 gram sub-sample was weighed into a drying can. The sub-samples were dried in a mechanical convection oven at 90° C. for 24 hours and then weighed.

The data were subjected to statistical analysis. It was first verified that the relationship of dry matter to specific gravity is linear. Following this a linear regression equation was fitted to the data from each field sample by least squares procedures. Specific gravity was considered to be the independent variable in this process. The intercept and slope constants of the individual regression equations were then considered as the basic variates for most of the remainder of the statistical analyses. The procedures used are discussd further in the appendix.

RESULTS

1948 Season:

The regression equations fitted to the different samples from the two locations in 1948 exhibited statistically significant differences, but they did not yield sufficiently different predicted dry matter values over the normal specific gravity range to cause any practical concern. It was estimated that the use of the average equation to predict dry matter for all potatoes would have yielded a prediction error* of 0.96 per cent dry matter on the average. The average equation for 1948 was:

Per cent dry matter = (205.14 Specific gravity) — 200.76. (Eq. 1)

The limited scope of the study combined with the finding of significant differences made it highly desirable to obtain more comprehensive data on the effects of location and variety. This was done in 1949. Although interest centered in potatoes of canning type, observations on potatoes of other sizes were made as a matter of general interest.

1949 Season, State-wide Study:

Significant differences were found to exist among the 28 regression lines fitted to the individual field samples from the state-wide study. Nevertheless, as is seen from figure 2, the lines do not differ much as regards the dry matter values they yield for a given specific gravity.

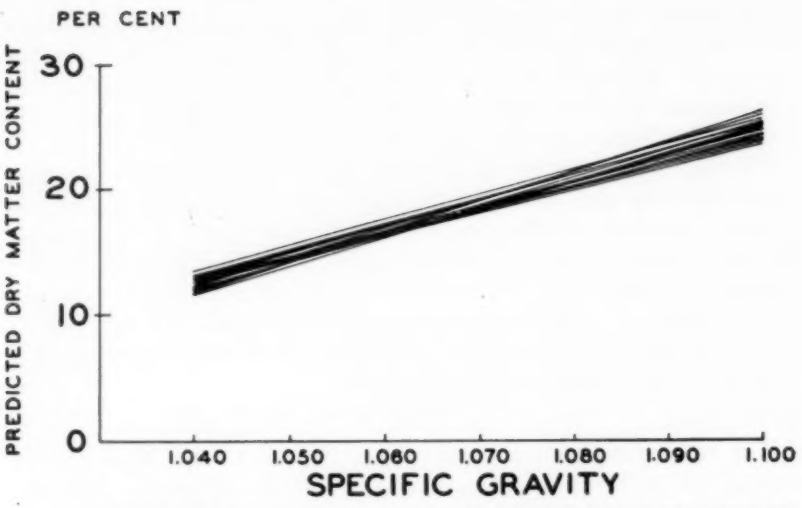
Averaged over all samples the equation for 1949 was:

Per cent dry matter = (206.55 Specific gravity) — 202.13. (Eq. 2)

The prediction error if applying equation 2 anywhere in the state to potatoes of canning size for the two predominant varieties (Sequoia in the west and Cobbler in the east) was found to be 0.51 per cent dry matter. For a given specific gravity, x, the prediction error is given by

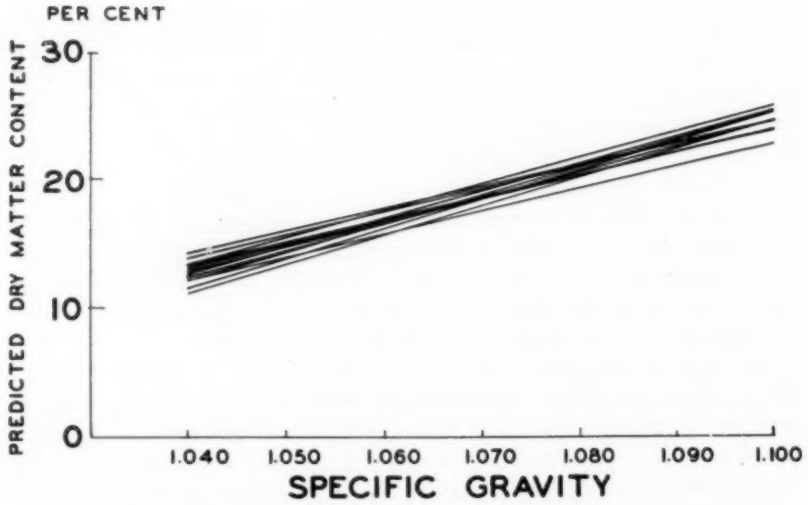
$$\text{Prediction Error} = \sqrt{177.5902 - 335.7274x + 158.9013x^2} \quad \text{(Eq. 3)}$$

*Approximately ⅔ of the time a predicted value will differ from the actual value by less than the prediction error. Approximately 95 per cent of the time the difference will be less than twice the prediction error.



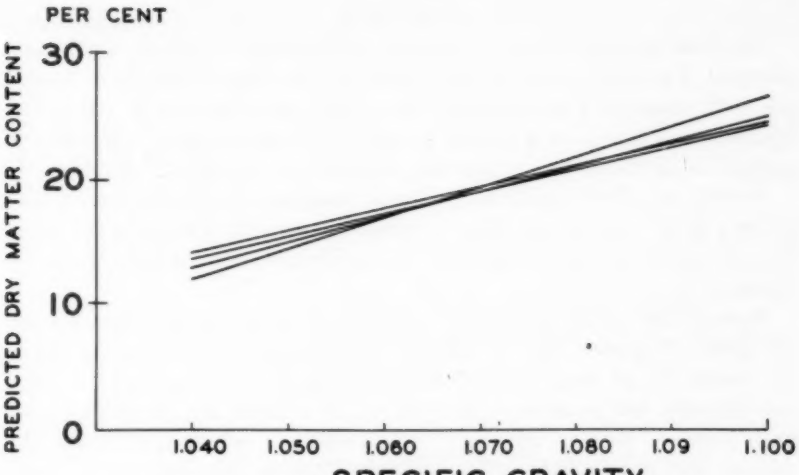
REGRESSION OF DRY MATTER CONTENT ON THE SPECIFIC GRAVITY OF POTATOES AS INFLUENCED BY LOCATION OF PRODUCTION

Fig. 2



REGRESSION OF DRY MATTER CONTENT ON THE SPECIFIC GRAVITY OF POTATOES AS INFLUENCED BY VARIETY

Fig. 3



REGRESSION OF DRY MATTER CONTENT ON THE SPECIFIC GRAVITY OF POTATOES AS INFLUENCED BY SIZE

Fig. 4

The variation between regression lines within the eastern and western regions was considerably greater than the variation between the average lines for the two regions. Practically no reduction of prediction error would be obtained by using separate regression lines for the two regions.

1949 Season, Varietal Study:

Statistically significant differences were found among the regression lines for the 14 varieties. The several lines are plotted in figure 3. As plotted, the varietal variations appear to be a little larger than the location effects illustrated by figure 2. Because of the smallness of many of the available varietal samples, however, the range of specific gravities was sometimes limited. The effect of this was to increase the variation in the fitted regression lines. The component of variability truly due to varietal differences, proved to be quite small.

1949 Season, Size of Tuber Study:

The differences between regression lines for the five size classes were not quite statistically significant. The effect of size, as illustrated in figure 4, appears to be about the same as that of variety, but the component of variability truly due to size turned out to be somewhat larger than that due to varietal differences. The failure to attain significance was caused perhaps by the limited number and size of samples available.

Discussion

The 1948 equation (Eq. 1) and the 1949 equation (Eq. 2) are almost identical. The 1948 equation represented no meaningful population as did the 1949 equation. This consideration in addition to the fact that the 1949 equation was based on a greater number of larger samples warrants the acceptance of the 1949 equation for practical use in North Carolina.

Strictly the 1949 equation applies to potatoes of canning size (1-1½ inches) of the two predominant commercial varieties grown in the state. If used solely in that connection, the prediction error is that given by equation 3.

Because the effects of variety and size of tuber on the equation are not great, it appears safe to use the 1949 equation for the prediction of dry matter for all potatoes grown in North Carolina irrespective of variety, size of tuber and location of production. If so used, the prediction error will increase, because the basic relationship is affected somewhat by variety and size of tuber. The estimated prediction error for a given specific gravity, after adding in the components due to variety and size, is given by

$$\text{Prediction error} = \sqrt{1044.3902 - 1961.0074x + 920.8013x^2} \quad \text{(Eq. 4)}$$

On the average this prediction error was found to be 0.74 per cent dry matter.

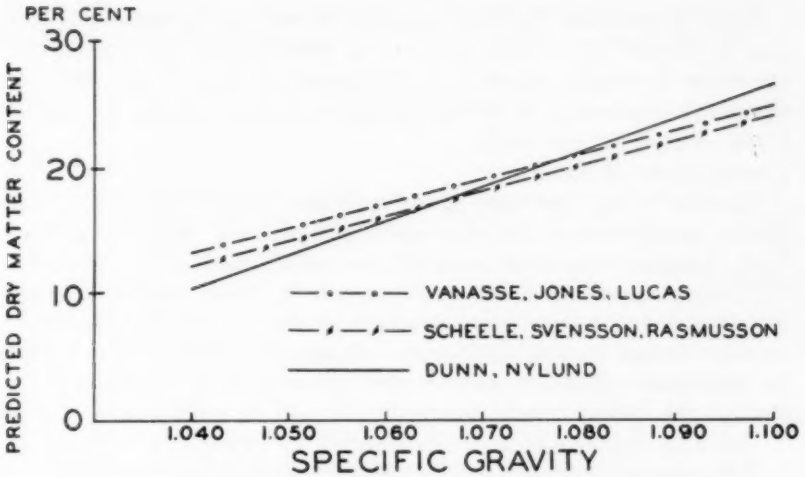
Comparison between the regression equations of Dunn and Nylund (2), Scheele *et al* (4) and the authors is shown in figure 5. The relationship between the regression line for the North Carolina potatoes and for that obtained by Scheele *et al* is strikingly parallel. There is nearly a constant difference in predicted dry matter values over a wide specific gravity range. It appears that the rate of change in dry matter content with increasing specific gravity is nearly the same for potatoes grown in Germany and North Carolina.

Summary

1. The specific gravity-dry matter relationship of potatoes grown in North Carolina was determined.

2. Location of production and variety of potato had a statistically significant effect on the specific gravity-dry matter relationship. Size of tuber was not significant but appeared to be somewhat greater than the effect of variety. These factors, though in some cases statistically significant, did not greatly affect predicted dry matter values.

3. A prediction equation and a prediction error were given for the estimation of dry matter content of potatoes from specific gravity measurements irrespective of size of tuber, variety or location grown in North Carolina.



COMPARISON OF REGRESSION LINES RELATING
DRY MATTER CONTENT & SPECIFIC GRAVITY OF POTATOES

Fig. 5

Statistical Appendix

The following material is given to outline the statistical procedures used in the foregoing study. Computational details will not be given, since the methods were, in general, standard ones.

Nature of the Specific Gravity—Dry Matter Relationship:

The earlier workers (2, 4) have reported that the relationship between dry matter content and specific gravity of potatoes is a linear one as follows:

$$y = bx + a \qquad \text{(Eq. 5)}$$

In this equation y = the dry matter content in per cent, x = specific gravity and a and b are constants. Preliminary plotting of several sets of data from this study indicated that the relationship was very close to linear over the range encountered for the variables. There was a suggestion, however, that the relationship might truly be a hyperbolic one, namely

$$y = \frac{b'}{x} + a' \qquad \text{(Eq. 6)}$$

Accordingly, both equations 5 and 6 were fitted to several batches of data by least squares procedures. The goodness of fit was almost identical for the two equations. This is explainable in part at least by the fact that the specific gravity of potatoes is close to 1.0 and that the relationship between any variable and its reciprocal is essentially linear if the variable takes values close to 1.0 as does the specific gravity of potatoes.

There is precedent for using equation 5 and certain equipment now used in practice for grading potatoes is calibrated on the premise that dry matter is linearly related to specific gravity. In view of this, and since equation 5 appeared to fit the data equally as well as equation 6, equation 5 was adopted for this study.

General Items of Procedure:

As noted in the text each of the numerous samples was graded into specific gravity classes and dry matter run on each class. Using these data, equation 5 was fitted separately for each sample. The values of *a* and *b* so obtained were then further analyzed. These analyses involved the sums of squares and cross products of the *a's* and *b's*. To discern whether various factors significantly affected the values predicted from the individual regression lines (in the region of most common specific gravity) the following ratio was used:

$$F = \frac{(\text{d. f. for effect})(T_{aa} + 2\bar{x}T_{ab} + \bar{x}^2T_{bb}) /}{(\text{d. f. for error})(E_{aa} + 2\bar{x}E_{ab} + \bar{x}^2E_{bb}) /} \quad \text{(Eq. 7)}$$

In this ratio, $\bar{X}$ = the mean specific gravity averaged over all samples; d. f. stands for degrees of freedom, T_{aa}, T_{ab}, and T_{bb} = the sums of squares and products of the *a's* and *b's* for the effect of interest, and E_{aa}, E_{ab}, and E_{bb} = either the sums of squares and products of the *a's* and *b's* for error or quantities analogous to E_{aa}, E_{ab}, and E_{bb} computed from the deviations from the individual regression lines (see below). This ratio was compared with tabulated F values at the 5 per cent level and appropriate degrees of freedom. The test was an approximate one in the current work because the *a's* and *b's* did not have uniform variances and covariances. This was due principally to variations in the range of specific gravity from sample to sample.

Specific Analyses:

The analyses for the 1948 data and the 1949 state-wide study were rather simple. To test for differences between individual regression lines the sums of squares and products for the numerator of equation 7 were computed directly from the *a's* and *b's*. The corresponding values for the denominator were obtained by averaging the variances and covariances of the individual *a's* and *b's*. The latter were computed from the deviations from the individual regression lines by the usual formulae.

In the varietal and size of tuber studies, a more complex analysis was necessary. In the varietal study, variety and location were partially confounded and in the size study, size and variety were partially confounded. In order to obtain tests of variety adjusted for location and of size adjusted for variety, least squares analyses were run on the *a's* and *b's* and on the quantities, $(a + b)$. The analyses on the *a's* and *b's* provided the quantities

T_{aa}, E_{aa}, T_{bb}, and E_{bb} for equation 7. The quantities T_{ab} and E_{ab} were then obtained from the analyses on the $(a + b)$'s, by taking advantage of the identity

$$ab = \frac{(a+b)^2 - a^2 + b^2}{2}$$

Prediction Errors:

The prediction errors (Eqs. 3, 4) may be expressed symbolically as

$$\sqrt{\text{Variance (a)} - 2x \text{ Covariance (a, b)} + x^2 \text{ Variance (b)}}$$

in which x is specific gravity. The variances and the covariance required for equation 3 were estimated directly from the sums of squares and products of the *a's* and *b's* in the 1949 state-wide study. To obtain the quantities for equation 4, the varietal and size components of variance and covariance were estimate from the least squares analyses outlined just above. The expectations of T_{aa}, T_{ab}, and T_{bb} were worked out, and the components were solved by equating the T's to their expectations. These components were then added to the corresponding quantities in equation 3 to obtain those in equation 4.

Acknowledgments

The assistance of Misses Eleanor Gibbs and Elizabeth Pearsall and Mr. Allan Garrison of the Food Processing Section of the Department of Horticulture, North Carolina State College, in obtaining samples and determining specific gravity and dry matter content is gratefully acknowledged. Thanks are also due to Mr. F. J. Verlinden who was responsible for the computational work involved in the statistical analyses.

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FLAVOR AND ODOR OF COOKED POTATOES AS AFFECTED BY USE OF LINDANE AND BENZENE HEXACHLORIDE AS INSECTICIDES

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Work of British investigators reported by Slade (11) in 1945, showed the potential value of the gamma isomer of benzene hexachloride (gammexane) in control of various insect pests. Subsequent tests by Thomas and Jameson (12) gave very encouraging results in wireworm control. Within the past six years in this country the effectiveness of benzene hexachloride as an insecticide in the control of wireworm infestation of potatoes has been proved (3, 6, 8, 15). It is also a well-established fact (1, 4, 5, 7, 8, 16) that this insecticide imparts to potatoes off-odors and off-flavors so objectionable that potatoes may be inedible after they have been cooked. Pepper, Reed, and Campbell (7) found that technical benzene hexachloride resulted in definite off-flavors in the tubers, whereas those grown in plots treated with refined and pure gamma isomer benzene hexachloride were much less offensive. Recently, advances have been made in the formulation of new insecticides as effective as technical benzene hexachloride but with less persistent odors and flavors. The name lindane has been established by the U. S. Interdepartmental Committee on Pest Control (14) as the common name for the gamma isomer of benzene hexachloride of a purity of not less than 99 per cent. The gamma isomer was shown by the British investigators (11) to be primarily responsible for the insecticidal activity of technical benzene hexachloride. Rohwer (10) has pointed out that in its pure form the gamma isomer does not have the characteristic musty odor associated with the technical product.

Rodriguez and Gould (9) reported that potatoes grown in lindane-treated soil were superior in flavor to those grown in technical benzene hexachloride-treated soil. Since lindane is a comparatively new product, the odor and flavor contamination through its use with food crops needs thorough investigation.

[1] Acknowledgment is made to Elsie H. Dawson of the Bureau of Human Nutrition and Home Economics for developing the sensitivity tests employed in the selection of the judging panel and to Albert B. Parks of the Bureau of Human Nutrition and Home Economics for making the statistical analysis of the data.

The purpose of the experiments reported here was to determine to what extent potatoes would have off-odors and off-flavors when cooked after they had been grown in soil treated (1) with lindane and technical benzene hexachloride the year prior to that in which potatoes were grown and (2) with varying amounts of lindane just prior to planting the crop. The treated and untreated samples of potatoes were grown by the Bureau of Entomology and Plant Quarantine in their experimental plots and the cooking tests herein reported were carried on at the request of that Bureau.

Experimental Procedure

In the first experiment a comparison was made of the cooking quality of three lots of Irish Cobbler potatoes grown in field plots at the Tidewater Field Station, Holland, Virginia[1]. The insecticides used in this experiment were lindane applied to the soil at a dosage of 1 pound per acre and technical benzene hexachloride at a dosage of approximately 8 pounds (1 pound gamma isomer) per acre. Two lots of potatoes were those grown in soils receiving the two treatments; the third lot was grown in untreated soil. Applications were made in connection with studies on the control of the southern corn rootworm in peanuts the year prior to planting the potatoes. The insecticides were diluted with pyrophyllite in order to facilitate their application to the surface of the soil at a uniform rate and were incorporated in the soil by cultivation soon after the application.

The second experiment was made to determine the effect of different dosage levels of lindane on the odor and flavor of potatoes without reference to insect control. Cooking quality studies were made with Katahdin potatoes grown at Beltsville, Maryland. The potatoes were grown in wooden boxes and also in 3-gallon crocks, three lots in soil receiving treatments of lindane at dosages of ¼ pound, 1 pound, and 4 pounds per acre and one lot in untreated soil. The insecticide was applied by thoroughly mixing it with soil before it was placed in the containers, which were sunk in the ground. Boxes and crocks for treated and untreated soils were arranged at random in the field.

All lots of potatoes used in both studies were harvested and stored a few weeks for preliminary curing before the cooking and palatability tests were made. After receipt in the laboratory, examination of the tubers showed all were firm and no spoilage was evident. None of the lots showed wireworm injury. All potatoes were stored at 75° F. for about a week until cooked.

Pared whole tubers were boiled and then mashed to obtain a well-blended sample for the taste tests. The tubers for each cooking sample were selected for uniformity of shape and thickness insofar as such

[1] Studies conducted in cooperation with the Virginia Agricultural Experiment Station.

selection was possible. The samples were cooked on consecutive days in order to have replicated tests, and were served to judges in random order.

Before boiling, the raw potatoes were washed, dried, sorted into samples (3 to 6 tubers depending upon size of tubers), weighed, and pared. Cooking was done on identical electrical units, in uniform enameled ware kettles of 3-quart capacity. Each potato sample was placed in a minimum amount of boiling distilled water (800-900 ml.) and covered with a lid. No seasonings were added. One tuber of each sample was threaded with an iron-constantan thermocouple with the thermocouple junction in the center of the tuber to measure the internal temperature as a control for doneness. A weighted thermocouple was placed in each cooking kettle to record the temperature of the water. Potatoes were cooked to an internal temperature of 96° C. as recorded by a potentiometer. Cooking water was drained off and samples weighed. The tubers were put through a ricer and stirred 30 strokes with a fork. Portions of mashed potatoes for judging were measured with a serving scoop into heated white porcelain dishes and coded for immediate scoring by the judging panel.

Palatability judging was done at individual tables in a room separate from that in which the samples were prepared. The room was adequately ventilated and lighted with artificial daylight lamps. A 3-to-1 judging scale, with 3 representing the highest score, was used with descriptive terms for each point on the scale. Samples were judged for odor, flavor, color, dryness, and mealiness.

The palatability panel consisted of four staff members of the Bureau of Human Nutrition and Home Economics who had had 3 years previous experience in scoring potato quality and some experience in detecting characteristic off-odor and off-flavor in potatoes contaminated with benzene hexachloride. The members of the judging panel knew that some of the samples had been treated with different insecticides in varying forms and amounts, and were asked to identify off-flavors whenever they were detected. Laboratory staff making the cooking tests did not serve on the judging panel. Tasting sessions were held in mid-morning.

Dilution Tests for Selecting Judges

It has been reported that individuals vary in their ability to detect the characteristic musty off-flavor of benzene hexachloride (2, 16). As a means of selecting a reliable judging panel from a group of 13 individuals experienced in judging potato quality, each person's threshold was determined. For this purpose, the gamma isomer, the one most used commercially, was employed. Benzene hexachloride containing 97.7 per cent gamma isomer was reduced to 25 per cent gamma isomer content by mixing with attapulgite clay. One per cent of Igepal CA-300 (an alkyl aryl polyethylene glycol ether) was incorporated in the mixture as a

wetting agent. Dilutions of this mixture were made up with distilled water to contain 2.5, 1.25, 0.25, 0.05, and 0.025 parts per million of gamma isomer. Since it has also been reported that more off-flavor is caused by some isomers of benzene hexachloride than by others (10), a second test was conducted to compare four isomers of benzene hexachloride in equal concentrations. To determine the relative off-flavor of these isomers, similar 25 per cent wettable powders of pure alpha, beta, gamma, and delta isomers of benzene hexachloride were prepared in dilutions of 0.25 parts per million of the isomers in distilled water.

To evaluate their performance, the individuals were ranked according to their sensitivity, duplicate detection on the two days' tests being used as the criterion for determining the threshold. Results of the test showed that the average threshold was 1.25 parts per million, 8 of the 13 persons showing this sensitivity. Of the other five persons, one detected 0.05 parts per million, two detected 0.25 parts per million, one detected 2.5 parts per million, and one gave no accurate duplicate judgments. The latter two persons were not selected for any of the palatability tests on potatoes treated with insecticides. In the various experiments judges were selected from the remaining group.

On the comparison of isomers in water solution, 12 of the 13 individuals duplicated detection of beta and delta isomers, and one individual (the one with highest sensitivity in the threshold test) also duplicated detection of alpha isomer. Detection of the gamma isomer was not duplicated by any individual.

Statistical Analyses

The palatability scores were analyzed statistically by analysis of variance and an attempt was made to further differentiate the means by the application of a method devised by Tukey (13). Within the limits of each test, the analysis showed no significant differences in mealiness, dryness, or color between samples receiving different treatments. Therefore the discussion in this paper will be limited to the effects of treatments on odor and flavor. Statistical analysis from the second experiment showed no significant differences between samples of different growing methods (box or crock) with respect to flavor and odor. Therefore, the combined scores for both growing methods were used in the analysis to determine treatment effects.

Results and Discussion

The potatoes used in the first experiment had been grown in untreated soil and in soil treated with lindane and technical benzene hexachloride for

TABLE 1.—*Means of judges' scores for odor and flavor of potatoes grown in soil treated with lindane and technical benzene hexachloride 1 year prior to planting*

Treatments	Pounds per Acre	Palatability Factors		Number Times Musty Off-flavor Detected[1]
		Odor	Flavor	
Untreated	None	3.0[2]	3.0	None
Lindane	1	2.4	2.1	11
Technical benzene hexachloride	1 (gamma isomer)	2.1	1.6	12

[1] In a total of 12 judgments.
[2] Means separated by lines are significantly different from each other at the 5-per cent level.

TABLE 2.—*Means of judges' scores for odor and flavor of potatoes grown in soil treated with lindane*

Treatments	Pounds per Acre	Palatability Factors	
		Odor	Flavor
Untreated	None	2.7[1]	2.7
Lindane	¼	2.5	2.4
Lindane	1	2.2	1.8
Lindane	4	1.4	1.2

[1] Means separated by lines are significantly different from each other at the 5-per cent level.

control of the southern corn rootworm the year prior to that in which the potatoes were grown. Mean scores for odor and flavor and the number of times a musty off-flavor was detected are shown in table 1. Each treatment mean was found significantly different from the other at the 5-per cent level for both odor and flavor. The scores for untreated potatoes were significantly higher than scores for potatoes grown in lindane-treated soil, and the lindane-treated were significantly higher than the scores for potatoes grown in soil treated with technical benzene hexachloride.

The off-flavor in the potatoes that were treated with technical benzene hexachloride was identified as benzene hexachloride by every judge in all replications. For the lindane-treated samples a musty off-flavor was identified in every judgment except one. The untreated sample had no impairment of flavor. A comparison of the scores indicates that treatments had less effect upon odor than upon flavor.

In the second experiment, the soil was treated with varying concentrations of lindane immediately prior to planting the potatoes. The analysis showed that each increase in treatment level of lindane resulted in a significantly lower score for flavor and for odor (Table 2). The level of significance between the untreated and successive scores is 5 per cent or less. That is, the mean score for the untreated sample was significantly higher than the mean score for potatoes treated with ¼ pound lindane; the mean score for ¼-pound treatment was significantly higher than the score for 1-pound treatment; the mean score for 1-pound treatment was significantly higher than the mean score for 4 pounds per acre treatment. The off-flavor was in most cases identified to be a musty off-flavor. All concentrations of lindane, as used in this experiment, caused some degree of off-odor and off-flavor. When 1-pound and 4-pound applications of lindane per acre were used, the musty off-flavor was intense and extremely undesirable. Higher scores for odor and flavor were obtained from potatoes treated with ¼ pound lindane per acre than any other treatment in this experiment. It must be remembered the cooked potato samples were unseasoned and judges were highly trained to detect presence of off-flavors. In practical use, the slight amount of off-flavor obtained from this treatment (¼ pound of lindane per acre) may be covered by seasonings of finished product.

When lindane was applied to the soil at the rate of 1 pound per acre the year prior to that in which the potatoes were grown the results indicate that odor and flavor may be slightly less affected than when the insecticide was applied the same year the potatoes were grown. However under the varying conditions of the two experiments, the indication of slight differences in amount of off-odor and off-flavor cannot be considered conclusive. Greenwood (4) has reported that although the soil was treated the year before with benzene hexachloride, any off-flavor detected in the potatoes was like that found in the crop grown the year the soil was treated, but off-flavor was less marked.

In all instances the tasters were able to distinguish between samples that had been grown on treated and untreated soil. The 1-pound dosage of gamma isomer of technical benzene hexachloride (about 8 pounds of benzene hexachloride) applied the year prior to planting showed more off-flavor than did the 1-pound dosage of lindane when applied either the year prior to planting or the same year. The results of the flavor tests showed that a greater amount of off-flavor was detected in cooked potatoes which were grown in soil treated with 4 pounds lindane per acre than in those from any other treatments.

Summary

The cooking quality studies conducted were for the purpose of comparing effects of different treatments on the odor and flavor of potatoes when grown in soil treated with lindane and with technical benzene hexachloride.

Palatability tests showed that both 1 pound of lindane per acre and about 8 pounds of technical benzene hexachloride (1 pound gamma isomer) per acre applied to the soil prior to planting imparted an objectionable flavor to cooked potatoes. The untreated sample had no impairment of odor or flavor. Each treatment mean was found significantly different from the other at the 5-per cent level for both odor and flavor. Technical benzene hexachloride treatment gave a stronger off-odor and off-flavor to the cooked potatoes than did the lindane treatment.

Scores for the different dosage levels of lindane applied the same year as planting the potatoes differed significantly from one another. The more lindane used per acre, the more off-odor and off-flavor were reported. When 1-pound and 4-pound applications of lindane per acre were used, the off-flavor occurring in the potatoes was intense and extremely undesirable With the application of lindane at the level of ¼ pound per acre, however, the typical musty odor and flavor, though detected, was slight and did not adversely affect the natural flavor of the potatoes.

The potatoes contaminated from soil treatments of 1 pound of gamma isomer technical benzene hexachloride per acre tasted more strongly of the insecticide than did those contaminated from either of the soil treatments of 1-pound applications of lindane. Of all the treatments tested, the 4-pound application of lindane per acre gave the most objectionable odor and flavor to cooked potatoes.

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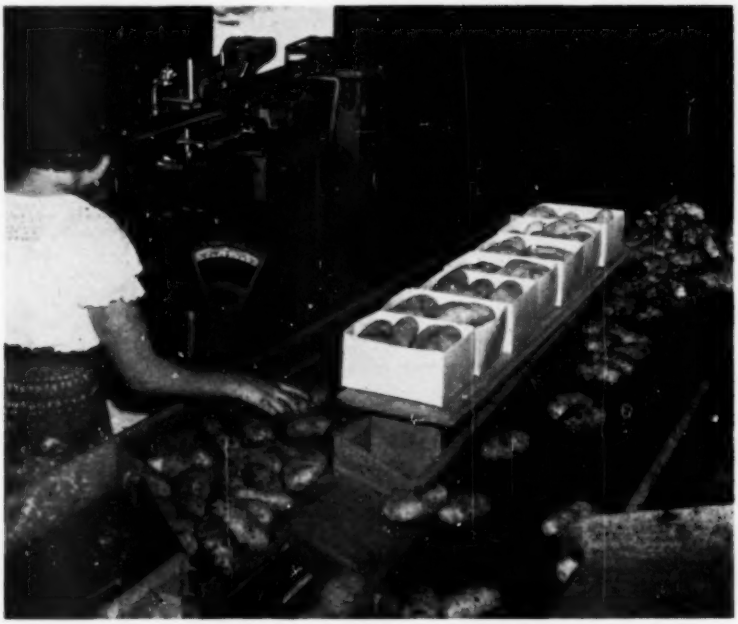

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